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Therapeutic potential and ownership of commercially available consoles in children with cerebral palsy

William Farr¹, Dido Green², Ian Male¹, Christopher Morris³, Sarah Bailey³, Heather Gage⁴, Sandra Speller¹, Val Colville⁵, Mandy Jackson⁵, Stephen Bremner⁶ and Anjum Memon⁶

¹Sussex Community NHS Trust, UK

²Oxford Brookes University, UK

³University of Exeter, UK

⁴University of Surrey, UK

⁵Parent partnership advisors, Sussex Community NHS Trust, UK

⁶Brighton and Sussex Medical School, UK

Abstract

Introduction: We conducted a survey amongst families of children with cerebral palsy (CP) to ascertain the ownership and therapeutic use and potential of commercial games consoles to improve motor function.

Method: 300 families in southeast England were identified through clinical records, and were requested to complete an anonymised questionnaire.

Results: A total of 61 families (20% response) returned a completed questionnaire with 41 (68%) males and 19 (32%) females with Cerebral Palsy, with a mean age of 11Y5M (SD 3Y 7M). The large majority of families, 59 (97%), owned a commercial console and the child used this for 50-300 minutes a week. Returns by severity of motor impairment were: Gross Motor Function Classification System (GMFCS) I (21%), II (31%), III (13%), IV (15%), V (18%). Consoles were used regularly for play across all GMFCS categories.

Conclusion: The potential of games consoles, as home-based virtual reality therapy (VRT), in improving the motor function of children with cerebral palsy should be appropriately tested in randomised controlled trial. Wide ownership, and the relative ease with which children engage in the use of commercial-based VRT systems suggests potential as a means of augmenting therapy protocols, taking advantage of interest and participation patterns of families.

Keywords

Cerebral Palsy, commercial consoles, survey

What the study has added

This study shows that there is wide ownership/use of commercial games consoles amongst children with CP; and this offers great potential to test therapeutic efficacy of home-based virtual reality therapy to improve motor function in children.

Key messages

Children with Cerebral Palsy frequently access and use commercial consoles during play at home.

Consoles are used by children across severity of motor impairment.

Some families had utilized home consoles for therapeutic purposes, with anecdotal improvements in motor function.

Opportunity exists for using commercial consoles within home based therapy protocols and for recreational participation across all GMFCS levels.

Introduction

Cerebral palsy (CP) has been described as “a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain.”

(Rosenbaum et al 2007:9). The heterogeneity of CP is further reflected in the frequency of co-occurring problems including: deficits in sensation, perception, communication, cognition and epilepsy (Rosenbaum et al 2007). As a result outcomes for children with CP vary with impairments impacting functional ability, participation in daily activities, and general quality of life (Imms 2008). Opportunities to participate in leisure activities are also limited (Skikako-Thomas et al 2008), with mastery motivation, as well as involvement with rehabilitation services, facilitating participation (Majnemar et al 2008).

CP affects up to 2 children per 1000 live births in the UK (National Institute for Health and Care Excellence 2012), or 254,000 global live births annually (World Health Organisation 2006). The delivery of therapy programmes that have sufficient regularity and intensity to engage children is a challenge, and the ‘ideal dose’ is not known.

Literature review

Interventions and adherence to therapy

A national survey of therapeutic interventions for children who have CP in the United Kingdom National Health Service found therapy time decreases as children age, from 12 hours per year for 0-6 year olds, to 7 hours for 12-18 year olds (Coombe et al 2012).

Fedrizzi et al (2003) cite how therapy time reduces for children with unilateral CP once they start attending school. Conversely, the amount of therapy time increases in line with severity rather than age (Fedrizzi et al 2003). The Gross Motor Function Classification System (GMFCS) defines the severity of CP from I-V with I being ambulatory and V being most severely physically affected and in need of full assistance for mobility (Josenby et al 2009). Children at GMFCS level I at 12-18 years are reported as receiving as little as 2.3 hours of therapy time per year (Coombe et al 2012). Intensive occupational or physical therapies for children aged 3-9 years e.g. constraint induced movement therapy (CIMT) show improvements in motor skills and self-care (i.e. less need for assistance), with the biggest gains seen in children at GMFCS levels I-II (Coombe et al 2012). Gains in upper limb function are also reported in older children (aged 7-16 years) who have major impairments in manual ability (Green et al 2013). There is therefore a need to capitalise on greatest gains in older children with milder forms of CP, without neglecting the increased support necessary when CP is more severe. VRT is a potential tool that could fill that gap (Wilson 2012).

The need for increased therapy across GMFCS levels and age groups could be aided in particular by home-based exercise programmes (Katz-Leurer et al 2009). As home exercise programmes are poorly tolerated by some children and their families, VRT in the home offers a potential mechanism to bypass problems of adherence to home exercise protocols by offering flexibility and thereby increase the number of settings where rehabilitation might take place (Wilson 2012, Weiss et al 2014). The past two decades have shown an increase in use of computers within school and computer

gaming, with children as young as six years playing electronic games for up to an hour daily (Ramos et al 2005). The potential to exploit this phenomenon with low-cost, off-the-shelf gaming systems have great potential as a clinical application (e.g. Deutsch et al 2008). Adopting VRT in the home will occur only when the full scope of what is already present in the home is known, alongside a clear understanding of the current state of VRT.

Virtual reality therapy

Virtual Reality Therapy (VRT) is a method that uses motion capture digital technology to assist with therapy (Bonnechere et al 2014, Levac et al 2012). Therapeutic potential of VRT has been explored using commercial systems like the Nintendo Wii™, Wii Fit™, Xbox Kinect™, or through the use of more personalised and bespoke systems such as MiTii (e.g. Boyd et al 2013, Deutsch et al 2008, James et al 2015, Jelsma et al 2012 Mitchell et al 2012, O'Donovan et al 2012, Shih et al 2012).

VRT as a complex intervention may work because of 'active ingredients' (Craig et al 2008, Levac et al 2012). Active ingredients are factors surrounding dose and/or intensity, or general factors such as the way that therapist and client interact (Whyte and Hart 2003). Levac et al (2012) identifies nine VRT active ingredients 1) *opportunities for practice* by duration, intensity and frequency of practice 2) *task specificity*, or how the activity relates to real tasks or actions 3) *flexibility to individualise treatment parameters* or how the system can be adapted to the user 4) *feedback* about how the user is achieving on tasks, and how this is relayed 5) *social play equalization* or how

interactive game play allows children to take part in social interaction without barriers 6) *neuroplastic changes* indicate how concrete neural pathways and cortical activation change may occur with VRT 7) *problem solving* or how the game provides tasks that are always changing but allow for practice 8) *motivation* 9) *role of support person* e.g. the ability of the therapist to guide rehabilitation, or the amount of parental involvement and enthusiasm.

Of the active ingredients, *neuroplastic changes* have positive results measured using functional magnetic resonance imaging (see Chen et al 2007). Weiss et al (2014) state many VRT techniques already have good *task specificity*. A growing body of evidence exists for *motivational* factors, yet sustainability of interest is proving to be a continued problem (e.g. see Bonnechere et al 2014, Weiss et al 2014). *Opportunities for practice* i.e. the importance of dose, frequency and timing, have also so far proved to be inconsistent as a reliable active ingredient (e.g. James et al 2015). The other outstanding active ingredients are according to Levac et al (2012) still being theoretically explored.

Methodological issues further hinder understanding of VRT. Lack of standardisation across research, especially with inconsistencies in method, has made adoption problematic (Bonnechere et al 2014). A large cohort of patients has now been in receipt of the VR therapy but in various formats with a variety of scales and scores that make comparisons difficult across studies (Bonnechere et al 2014, Snider et al 2010).). There is as yet for example no single gold standard for measuring outcomes, although the Gross Motor Function Measurement comes close (Farr and Male 2013). Current studies with VRT may also suffer from bias due to unknown motivational

aspects or hidden effects of digital systems, and /or selection bias (e.g. if boys like a gaming system more than girls), in addition to availability of technology in the home. Before home-based VRT can even be successfully trialled (e.g. see Levac and Miller 2012), an understanding is needed of the availability of computerized gaming systems within the home and the usage and role these play for the child and family.

Aims of the study

This survey was the first stage in a study funded by the National Institute for Health Research (NIHR) focusing on the feasibility of use of the Nintendo Wii Fit™ in the home as an addition to regular therapy care for children with CP (study and ethics ID blind for peer review). The survey investigated the ownership and use of commercial games consoles, including active games consoles, in the home amongst families of children with CP. Additionally it identified whether these systems had been used as clinical therapeutic interventions, and what parents' perceptions were of improvements in motor function following use.

Methods

Recruitment and consent

Children with CP were identified from clinical lists of Community NHS Trust Child Development Teams in a Southern county in England. Parents were approached either by the clinical team during regular appointment, by the research department after referral from clinical team or through postal invitation from participating child

development clinical teams. Questionnaires were provided directly to parents by attending clinic and by clinician, or by post together with written information leaflet. Inclusion criteria were: diagnosed with CP; any level of movement ability (GFMCS levels I-V) child of school age 5-16 years old; and, under the care of local NHS staff. The sample was taken from across a county in the south east of England where there is mixed socio-economic income (Gill 2015).

Contact was made via postal survey or parents were approached by filling out the survey before or after attending regular clinical appointments. Participants were given time to read the patient information sheet, and ask questions about the study before taking part. Consent was assumed by return of the completed questionnaire and was made clear in information leaflets. Patient information sheets were produced for adults, children over 8, and children under-8 years of age.

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Distribution

Three hundred questionnaires were sent out to child development teams in the south east of England based on estimates of approximately 300-350 children with CP across all GMFCS levels living in the area. Surveys were divided up into blocks of 50 for 5 local child development centres (CDCs) and a specialist unit for children with complex motor disorders. All questionnaires were supplied with stamped addressed envelopes. Information was not tracked by each CDC on distribution following clinical appointment or by post. Each CDC and the specialist unit was given 20 additional copies of the recruitment letter, patient information sheet, and a poster to advertise the study and stamped addressed envelopes for return of paper questionnaires. No additional copies were given to the specialist unit as clinical staff did not think it would be necessary due to low numbers of participant population. It was decided not to distribute surveys on-line, as it would not be possible to control for data contamination if filled out by individuals outside of the focus geographical area. Data collection took place over a four-month period.

Measures

Parents were asked to complete a survey consisting of five questions (see appendix for full survey):

- Enquiry as to the type of any consoles in the home
- How many hours each week were spent playing on the console(s)
- Whether the child had ever used a gaming system as a treatment or therapy

- What that system was – if identifiable – and if the system in the parent's opinion helped improve motor function.
- About the child's motivation for the system, whether they liked doing games as therapy, and how easy it was to encourage their child to participate in the programme or games.

Analysis of Findings

Quantitative data were analysed using basic descriptive statistics (frequency, means). A medical statistician produced the quantitative results from an anonymised dataset using Stata (Stata 2015). Two researchers read the qualitative comments. Main issues were extracted using thematic analysis, with a semantic level of interpretation where only explicit comments made by respondents were identified and arranged into themes (Braun and Clarke 2006).

Results

Characteristics of respondents

Respondent characteristics are shown in table 1. Sixty-one questionnaires (20%) were returned. Two CDCs confirmed complete distribution (100 surveys), two more CDCs distributed half of the surveys (50 surveys in total) and two CDCs did not document distribution. The majority of surveys were returned by post (42/61) or following face-to-face contact at clinic after care teams asked if they were willing to participate (19/61). Surveys were reported for 68% male and 31% female children with CP. Breakdown by

gender and GMFCS level was: I, 7 males = 11.5% , 6 females =9.8% ; II, 14 males = 22.9% , 5 females = 8.2%; III, 5 males = 8.2%, 3 females = 4.9%; IV, 6 males = 9.8%, 3 females = 4.9%; V, 9 males = 14.8%, 2 females = 3.8%. Returns increased across age groups from 23% for 5-8 year olds, 36% for 9-12 years and 41% for 13-16 year olds (median age 11Y 5M; SD 3Y 7M). Returns by GMFCS levels were highest for Level II (19/61, 31%) with more families with male children represented at GMFCS levels III-V. Frequency of respondents by gender and GMFCS level is shown in figure 1.

Insert table 1 here

Console ownership

Ninety-six percent (59/61) of all households owned a commercial console. Console ownership by respondents fell into four main console types; Nintendo™, Microsoft™, Playstation™ and Apple™ systems. Two households had no commercial system. The Nintendo Wii™ (N=37), Wii Fit™ (N=16), and Nintendo DS™ (N=26), along with the Xbox™ (N=26) and Xbox Kinect™ (N=15) accounted for the majority of ownership, with 120 (68%) out of 176 consoles in 61 households. The Apple iPad™ whilst not classed as a console was included by most parents as a commercial gaming system (N=22).

Console use

The average number of minutes played by console per week varied considerably and did not reflect volume of ownership (figure 2). Overall, most children used their device for interaction as a non-physically interactive games console for leisure. The iPad was the most used piece of equipment on a weekly basis with an average of over 300 minutes per household per child, per week, followed by the Xbox (150 minutes per week). It is worth noting that iPad data were gathered under the 'other' column so figures reported here may well be higher, as some recipients may not have included the iPad in their amount of weekly use as this information was not specifically sought.

Insert figure 1 here

Previous therapy with commercial consoles

Children who have used a commercial console system as a treatment or therapy, as understood by a parent, made up 28/61 responses (46%), with the Wii™, the Wii™ Fit as the most common device that had been used (18/28). One parent reported the use of a bespoke piece of software for improving motor function and was part of a research project at a university. Two other parents reported using the PC for keyboard practice to focus on fine-motor skills, and another parent was utilizing the iPad for their child with a similar outcome, but none of these three families were following a specific programme of therapy.

Insert figure 2 here

Impact of commercial consoles

Parents who used commercial systems for therapy (18/61) reported that they had not caused any worsening of motor function. The remaining participants (43/61) did not respond to this question. Thirteen parents (13/18, 72%) reported slight to large improvements in motor function when using commercially available consoles, but this represented a small proportion (13/61, 21%) of the overall survey. The devices perceived to cause no change were the Nintendo Wii Fit™ (4/18) and the Microsoft Kinect (1/18). Two parents reported the Apple iPad having a positive impact on motor function.

Insert figure 3 here

Children's attitudes to commercial consoles

The majority of children's attitudes to games as therapy on commercial consoles (as reported by parents) were positive; 15/26 respondents, (73%) indicated that their child 'liked' or liked 'very much' the idea of doing games as therapy. Six children (23%) 'did not mind' doing therapy virtually, one child indicated that they did not like doing games as therapy. Furthermore, parents reported having little problem encouraging, motivating or prompting their child to participate in the games when used as therapy. Parents stated children were able to do the games in a self-initiated way

(52%, 14/27) or with minimal prompting (30%, 8/27), whilst some 18%, (5/27) needed 'much prompting'.

Thematic analysis

Thirty-two parents provided free text comments regarding virtual reality therapy. These broadly fell into three main themes: type of therapy and games-play, accessibility, and levels of engagement.

Type of therapy and games-play

The most reported parental comment was questioning of therapeutic potential of the gaming system. Parental understanding of console 'games' and 'gaming' and whether these could be therapeutically used was not explored or identified as a theme. However, parent perceptions of consoles was pragmatic with concerns shifting to therapeutic value of the console, but without indicting whether this was the games (software) or consoles (hardware).

Parents responding to the survey had either bought a console in the past, or their child had used systems in schools, but all were pro-active, interested, wanted to know which systems might be beneficial for their child. Parents listed games or activities that had been attempted in the past, or the way the games worked (e.g. creating cause and effect). Parents additionally listed what they thought being targeted by the use of commercial systems, whether a specific skill, or a certain type of function such as balance, or a particular muscle group; "used balance game on wii fit to try and become

aware of balance/weight distribution"... "we tried when she was younger to help with balance, but she found it tiring... "a few minutes [of therapy using a console], very rarely. Worked on upper limb".

Accessibility

Parents expressed concern about whether children would be able to use consoles unaided, and if so, what adaptations would be made to the console system. They were concerned about the amount of help children would need, especially if the virtual reality therapy system was to be used in the home. Parents were also concerned about whether their child would be able to understand instructions given by a console.

Levels of engagement

Parents were concerned about the amount of motivation children would need to sustain a programme on a commercial console e.g. one parent reported that their child "initially needed much prompting". Seven parents stated that children would get bored, or frustrated with a system, with a further nine parents indicating that demands of individual games e.g. whether two hands were needed to play, or if their child could balance independently on balance board would dictate the value of any system. For example one parent commented that therapy using consoles:

"Encourage[d] balance and coordination at the age of 6-8 years. Helped with a lot of things as part of a package of care. It was a fun way of doing physio, until the novelty wore off."

Parents were therefore concerned about the sustainability of commercial systems to engage children for any sustained length of time.

Discussion

Our survey found that most responders to the survey were in possession of low-cost, off-the-shelf gaming system (Deutsch et al 2008). The availability and frequency of use of these technologies at home provide opportunities to exploit typical daily play and leisure activities for either therapeutic purposes or even as an outcome measure. However, parent generated responses must only be taken as indicative of potential improvement in motor function which could be attributed to VRT. Additionally, this also neglects any psychosocial benefits that parents may attribute to console use, which was not explored in the questionnaire.

In considering the potential use of VR systems as home based therapeutic adjuncts, a number of families reported using commercial systems for therapy goals. Those that had used a system with therapy objectives did not report any detrimental effects, with most parents noticing some improvements in motor function. Furthermore, parents reported that their child 'liked' or 'liked very much' the idea of doing games as therapy with many self-initiating participation. Higher levels of engagement alongside mastery motivation have been shown to enhance therapy outcomes for children with unilateral CP (Miller et al 2014). This is not necessarily reflected by increased adherence to therapy protocols, despite positive outcomes, using a purposively designed computerized interactive gaming system (MiTii™) in the home (James et al 2016, Mitchell et al 2016). Sakzweski et al. (2016) and Mitchell et al.

(2016) recently found children with acquired brain injury or cerebral palsy respectively, to have more limited engagement with the MiTii™ with either boredom or frustration (or other factors) reducing participation and adherence over time. The limited acceptability by children with movement problems for use of a semi-bespoke system, designed to address motor and perceptual impairments, has implications for applications of VR and computer-based therapies within the home context. On the one hand games and activities within bespoke and semi-bespoke systems are more readily scaled to meet individual needs and capacity (avoiding frustration). On the other hand, these systems may not be seen as fun and playful but rather, perceived as ‘therapy exercises’ and hence lack intrinsic motivation to capture the children’s interest over time.

Parents’ comments reflected these concerns regarding the capacity of a commercial system to sustain sufficient engagement over time. Additionally, parents worried about the level of support that children might need to be able to access and use a commercial system for therapy and wanted professional advice about what games to encourage and what therapeutic benefit there was in consoles. Similarly, other studies have reported therapists as having positive attitudes towards the adoption of VRT, but were concerned about available professional time, and having knowledge about the technology or intervention, so as to advise appropriately (Glegg et al 2013).

Of note in our findings was the bias of respondents from parents of older children. This may reflect a decrease in opportunities for age-appropriate recreational activities and or the reduction in therapy intervention levels delivered for older children, with parents keen to identify new formats of therapy for older children. Children at

GMFCS level I between 12-18 years have been reported as receiving as little as 2.3 hours of intervention per year (Coombe et al 2012). Yet these children were seen to be using commercial systems for between 50 to 300 minutes per week; suggesting that home-based VRT using commercial systems may be an acceptable and viable way to enhance therapy input and subsequent outcomes for older children (e.g. see Katz-Leurer et al 2009, Novak et al 2009). Poor take-up of home-based exercise protocols for children Sakzewski, 2016) may be compensated for if commercial systems show an advantage to adherence to therapy, particularly as systems are already present in many homes. What remains to be seen is the extent to which commercial systems, which are perceived as typical recreational computer/VR systems can perform a dual role as therapeutic adjunct alongside facilitating participation in play and leisure activities. Bias may also be present in the gender imbalance of respondents with two thirds of responses coming from families with males even though CP is more common in males (SCPE, 2002)

Limitations

These results represent a small sample of 61 children (20% response) and represents a limited geographical area, and the socio-economic background of respondents is unknown. A broad comparison with typical postal response rates shows return can vary from 20% - 60% (e.g. Edwards et al 2002; Asch et al 1997).

The questionnaire was compiled by a clinician, and cleared by the steering committee of the project, and received national ethical approval. The questionnaire was not a standardized tool, and questions were checked for acceptability by a parent

consultation group and were considered to have good face validity during development. The questionnaire was not subject to any follow up letters, phone calls and was not put on coloured paper (all recommended for improving higher return rate) due to financial constraints.

Scores were subjective and relied on parent's interpretation of terms and definitions such as 'treatment' and 'therapy'. Scales were limited in response, often with only three choices. One oversight was the lack of inclusion of iPads as presented technology.

Questions on which there were few responses e.g. with regards to impact of devices on motor function, were too limited to draw conclusions. The data presented here must be taken as illustrative of potential, rather than representative of the issues facing the adoption of VRT across health services. Nevertheless, this survey starts to clarify commercial console ownership in the home with respect to usage, types of systems and potential for targeting VRT by gender and by severity of CP.

Therapeutic implications

Commercial-interactive (gaming) systems are an inherent part of children's modern lives, as much for children with disabilities as for typically developing children. With the availability of therapy restricted but the accessibility of technologies becoming more affordable, home-based therapeutic use of VRT is compelling. This will not be possible until more evidence is available as to the clear therapeutic impact of systems. This survey shows a potential therapeutic target for VRT in children with CP to not only

support motor skill acquisition but to enhance participation in age-appropriate recreational activities.

Conclusion

Parents and families appear interested in the use of commercial consoles for children with CP across all levels of severity, where potential therapeutic benefits could extend from balance in ambulatory CP (e.g. GMFCS I and II) to upper limb function and control in more severe CP, reflected in widespread iPad use. Parents are actively engaged in processes to find new modalities of therapy for their children especially as children appear motivated to use commercial systems. The relative ease of encouraging children to engage in use of commercial-based VRT systems suggests potential as a means of augmenting therapy protocols within meaningful daily recreational activities.

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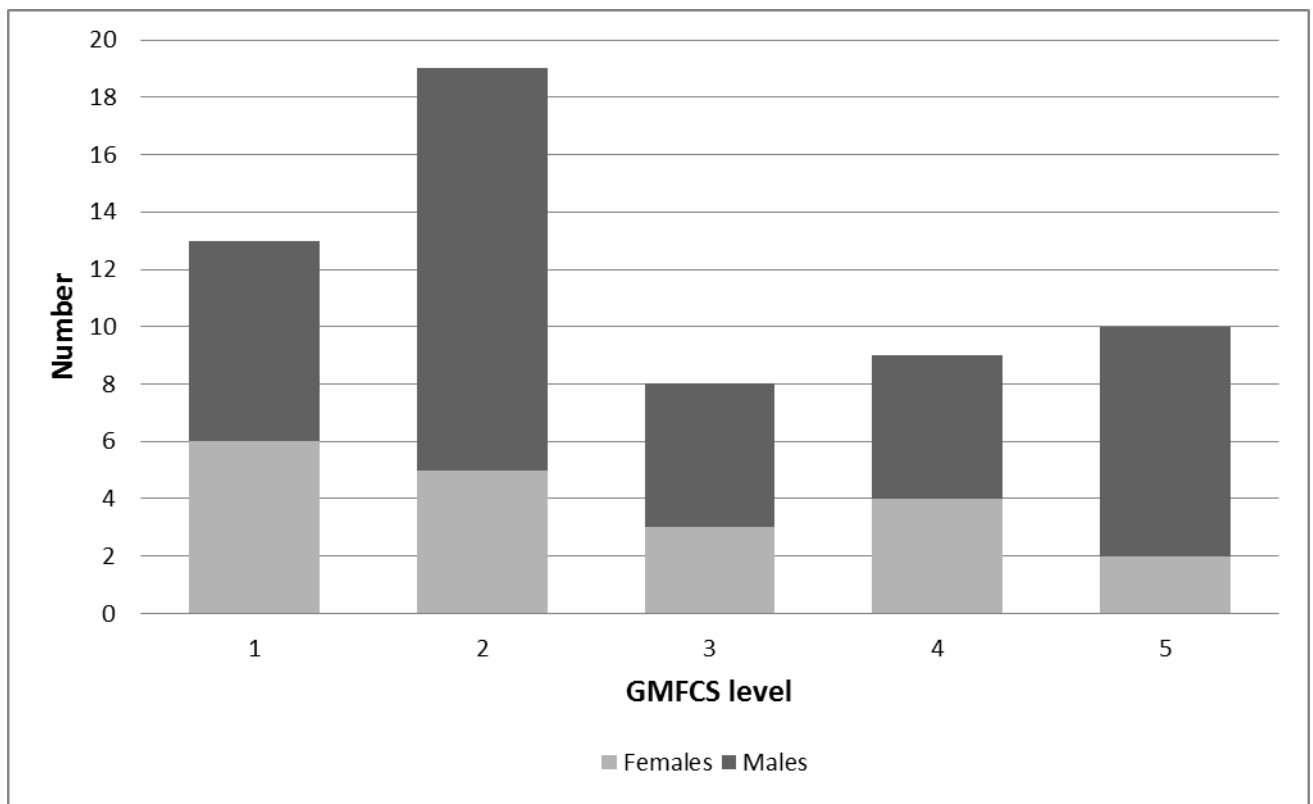
Table 1. Respondent characteristics arranged by Gross Motor Function Classification System Level

| GMFCS* | Level I | Level II | Level III | Level IV | Level V |
|--------------------------------------------------------|-------------------|---------------------|------------------------|--------------------|-------------------|
| Level | | | | | |
| N (Mean Age Years, Range) | 13 (10.7, 5-16.1) | 19 (11.3, 5.2-11.3) | 8 (13.39, 11.5 – 15.3) | 9 (10.4, 5 - 16.2) | 11 (11.1, 5-16.2) |
| Gender M / F | M 7, F 6 | M 14, F 5 | M 5, F 3 | M 6, F 3 | M 9, F 2 |
| Number of Home consoles (Mean, Range) | 38 (3.5, 0-6) | 45 (4, 0-7) | 21 (1.9, 0-5) | 26 (2.4, 1-6) | 21 (1.9, 1-4) |
| Hours consoles used per week (Median) | 111.95 (3) | 100.25 (1) | 78.6 (8.5) | 93 (5) | 52 (0.5) |
| Hours consoles used for therapy all time (Mean) | 3 (0) | 9 (0) | 7 (1) | 3 (0) | 3 (0) |

GMFCS = Gross motor function classification system, V is severest; N = number of respondents; M = Male; F=Female

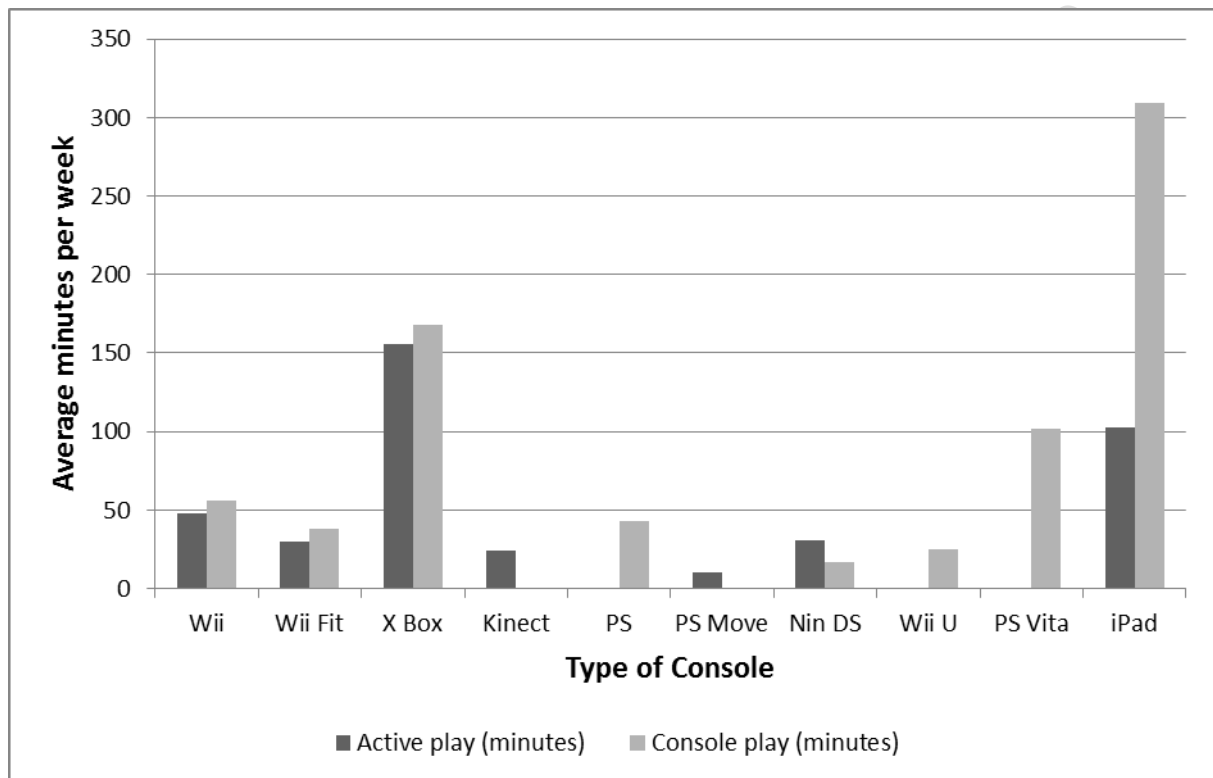
*1 individual did not indicate GMFCS level

Figure 1. Number of respondents by Gender and GMFCS level.



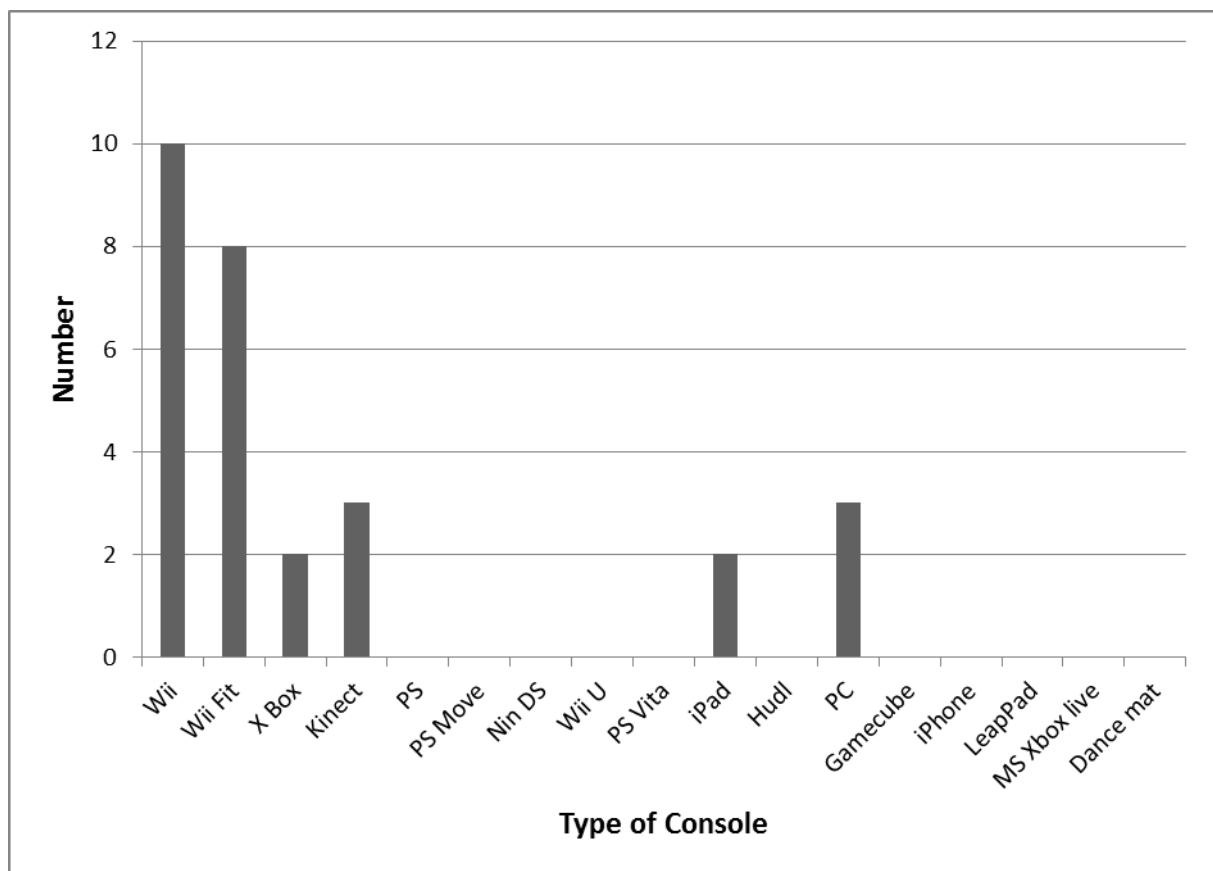
GMFCS = Gross Motor Function Classification System

Figure 2. Number of hours children play on commercial consoles on average per week.



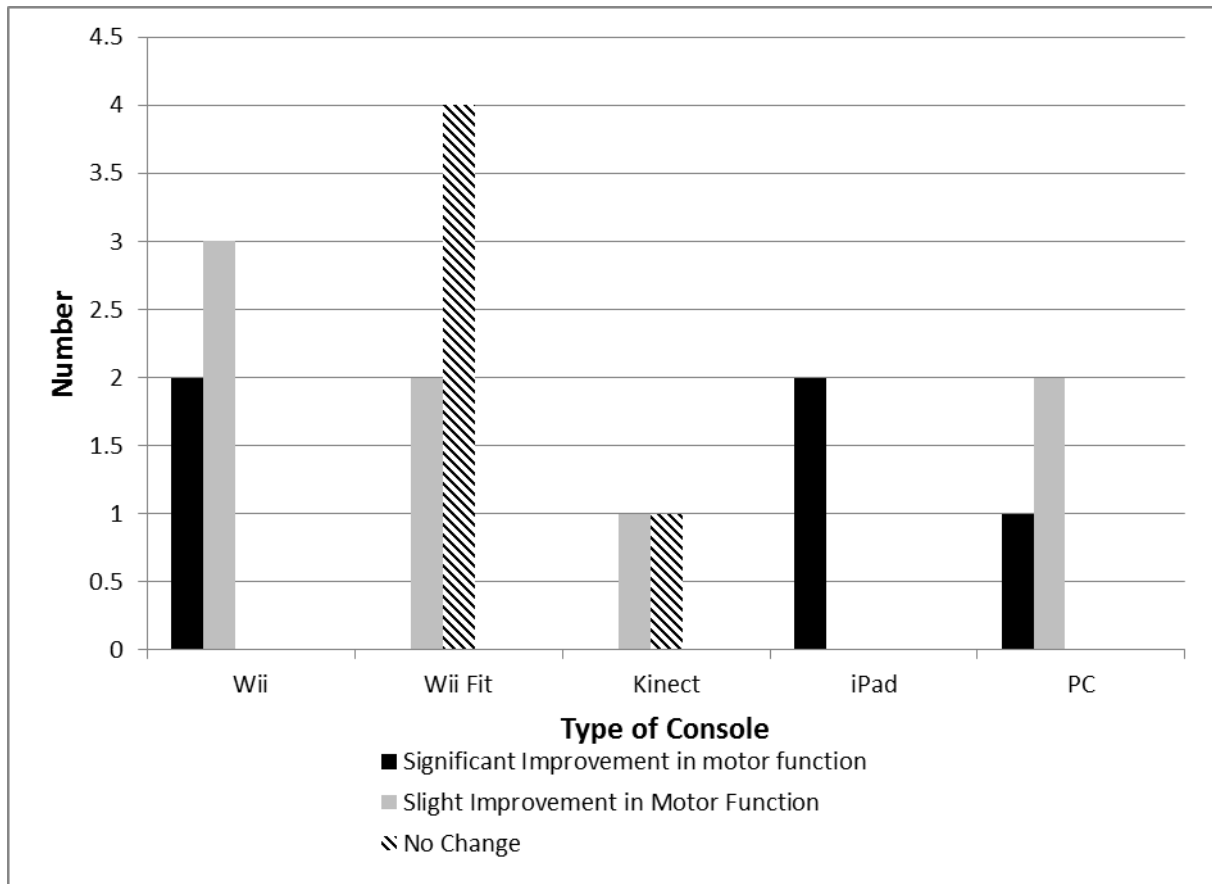
PS=Playstation; Nin DS=Nintendo DS

Figure 3. Number of children who have used a gaming system as treatment or therapy to improve motor function. N=28 respondents.



PS= playstation; PC = personal computer

Figure 4. Number of children whose parents reported device impact on motor function.



PC = personal computer